

The “how” and the “why” of rib fracture stabilization- a literature review

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Abstract

10%-15% of all trauma events will present thoracic trauma [2]. Chest wall trauma is becoming more and more significant due to the rising number traffic accidents [4, 5]. This condition usually features flail chest, deformation of the chest wall with rib disposition, comminution fractures of the ribs or sternum, incidents which ultimately determine a retraction of the thorax and incapacity [6, 7]. The purpose of this paper is to review available literature about rib fracture treatment. A systematic review of randomized-controlled trials that compared surgical management of broken ribs against conservative treatment was conducted. Study identification was performed through PubMed, Trip Database and Medscape. Titles and abstracts of all matching keywords were screened for relevance prior inclusion. 1380 publications were screened in order to perform our study. After excluding records that did not meet language and eligibility criteria, only 4 full texts remained. A total of 431 patients were pooled for analysis. 205 (47%) received surgical treatment and 226 (53%) were treated using conservative methods. The age mean was 46.33 years in the surgical group and 47.66 years in the conservative group. Surgically treated patients presented 6.3 fractured ribs (mean), while conservative treated patients 5.95 fractured ribs (mean). Pulmonary contusions were present in 90 operated patients and in 103 conservative treated patients. Thoracic deformity was noted in 71 patients treated surgically and in 94 non-surgically treated patients. The surgical group spent 5.62 days (mean) on mechanical ventilation and 8.19 days (mean) in the ICU, while the conservative group spent 7.66 days (mean) on mechanical ventilation and 10.14 days (mean) in the ICU. Hospital stay was shorter for surgically treated patients 16.09 days (mean) compared to 19.47 days (mean) for conservative treated patients. Pneumonia rates were also lower in the surgical group (32 patients developed pneumonia compared to the 53 patients in the other group). In terms of mortality, 10 patients died: 3 that received surgery and 7 that received conservative treatment. Although a relatively small number of patients were included in this study, the above results still raise the question of whether surgical intervention or conservative treatment provides the best outcomes (both short and long-term) of patients. Indications for operative management of fractured ribs are still shrouded in controversies, and challenges. Further research is required in this domain in order to properly establish a guideline regarding patient selection, stabilization method and outcome.

Keywords: rib fracture management, osteosynthesis, flail chest, thoracic trauma

INTRODUCTION.

Nowadays trauma has become one of the main causes of death around the globe [1]. According to Eurostat statistics, in 2016 3.2% of all deaths were linked to various accidents. In the European Union young people are predisposed to be involved in road accidents, while older generations are more likely to suffer some kind of accident at home [2].

10%-15% of all trauma events will present thoracic trauma [2,3]. Chest wall trauma is becoming more and more significant due to the rising number traffic

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accidents [4,5]. This condition usually features flail chest, deformation of the chest wall with rib disposition, comminution fractures of the ribs or sternum, incidents which ultimately determine a retraction of the thorax and incapacity [6, 7].

Thoracic trauma assessment includes all the usual exams and studies required in a major trauma patient (including blood gas). The exploration of choice is the CT scan, especially with 3D reconstruction. Laboratory results help in the process of monitoring the patients for imminent respiratory failure [12, 14].

Rib fractures can be caused due to sport activities, falls, blunt force trauma, non-accidental injury, severe coughing, cardiopulmonary resuscitation maneuvers or bone tumors. The more broken ribs a person presents, the more likely increased morbidity and mortality are likely to occur [41]. The most frequently fractured ribs are the ones between the 4th and the 9th ribs. Fractures of the first two ribs are the result of a powerful trauma by which concomitant major vessel lesions or neurological injuries are mundane. Upper rib fractures favor direct penetration of the lung parenchyma while lower rib fractures favor pleura or the abdominal organs [8, 9, 10, 11].

Flail chest is a post-traumatic medical condition in which 3 or more ribs are fractured at least in 2 locations and a section of the chest wall moves independently of the rest of the thorax. It interferes with respiratory physiology and can lead to an unfavorable evolution [12]. Flail chest can be classified as: anterior (associated with sternum pathology, with fracture foci concerning only the bone component or the bilateral costochondral joints); lateral or anterolateral (with fracture foci regarding both the bone and cartilage matrix of the ribs); and posterior or posterolateral [13].

The purpose of this paper is to review available literature about rib fracture treatment focusing on whether surgical approach provides better results compared to conservative management.

MATERIALS AND METHODS:

A systematic review of randomized-controlled trials that compared surgical management of broken ribs against conservative treatment was conducted. Research was performed through PubMed, Trip Database and Medscape. Titles and abstracts of all matching keywords were screened for relevance prior inclusion.

The Centre for Reviews and Dissemination [46] recommendations were utilized in order to perform this study.

Eligibility criteria

The studies fulfilled the following criteria:

Target population: adult patients who had suffered traumatic fractures of the ribs, with or without flail chest.

Intervention: any surgical procedure performed on the patients in order to stabilize the rib fractures.

Comparator: any type of surgical fixation and conservative treatment.

Outcome: duration of ICU stay, ventilator support, pneumonia rate and total length of hospitalization.

Literature search

Inclusion: Papers published between 2015 - 2019 comparing surgical management in adults with rib fractures with conservative treatment were included in this study.

Exclusion: Studies that were written in a language other than English and Romanian

Search Strategy:

PubMed and Medscape were searched using “rib fracture”, “rib fractures” AND “surgery”, “surgical fixation”, “osteosynthesis”

Trip Database was searched using “surgical management rib fracture randomized controlled trials” AND “randomized controlled trials comparing rib fracture management”

1380 publications were retrieved. After removing the duplicates we obtained 26 papers. After applying the exclusion and eligibility criteria only 4 full texts papers remain. [47,48,49,50]

RESULTS:

The data regarding the patients, diagnosis, number of days spent in the hospital and in intensive care, mortality rate and treatment are presented in table I, II.

A total of 431 patients were pooled for analysis. 205 (47%) received surgical treatment and 226 (53%) were treated using conservative methods. Surgical approach included one of the following methods of rib fracture stabilization: Synthes MatrixRIB fixation system, AO standard 3.5 mm reconstruction plates and cancellors screws and nickel titanium alloy devices.

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Table I. The data regarding the patients, diagnosis, the hospital stay, mortality rate and treatment

	Liu T et al [50]		Meiguang Qiu et al [49]		Wei-Ming Wu et al[48]		Jaclyn Farquhar et al [47]	
Number of patients	N = 50		N = 162		N = 164		N = 55	
	Surgery	No surgery	Surgery	no surgery	Surgery	no surgery	Surgery	no surgery
	25	25	86	76	75	89	19	36
Gender (M/F)	N/A	N/A	61M: 2 F	54M:22 F	75 M:0F	89M:0F	15M:4F	25M:11F
Age(years)	N/A	N/A	37.19±12.4	35.96±13.03	52 ± 4.5	51 ± 3.1	53.1 ± 14.3	56.5 ± 15.9
Presence of pulmonary contusion (N pts)	N/A	N/A	N/A	N/A	71	82	19	21
Thoracic deformity (N pts)	2	9	3 with flail chest	11 with flail chest	67	77	N/A	N/A
Mechanical Ventilation (days, mean)	7±4 days	9±5 days	5.71 ± 1.35 days for patients with flail chest	9.06 ± 3.58 days for patients with flail chest	3.7 ± 1.4 days	9.5 ± 4.3 days	6.1 ± 5.9days	3.1 ± 5.5 days
ICU stay (mean)	10± 5days	12±6 days	7.19 ± 1.67days for patients with flail chest	10.29 ± 2.31 days for patients with flail chest	8.2 ± 4.3days	14.6 ± 3.2days	7.4 ± 6.7days	3.7 ± 6.0 days
Hospital stay(mean)	N/A	N/A	11.09 ± 1.88 days without flail chest	15.93 ± 2.75 days without flail chest	15.3 ± 6.4 days	26.5 ± 6.9 days	21.9 ± 13.2 days	16.0 ± 12.1 days
Pneumonia (N pts)	12	20	3 without flail chest	10 without flail chest	5	17	N/A	N/A
Tracheostomy (N pts)	N/A	N/A	2 with flail chest	8 with flail chest	4	7	N/A	N/A

Mortality (N pts)	N/A	N/A	1 flail chest	2 flail chest	1	4	1	1
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Table II

Pooled analysis obtained from the 4 studies is portrayed in table 2.

	Surgically treated patients	Conservative treated patients
Sex	46 male,33 female	79 male: 33 female
Age mean(years)	46.33	47.66
Nr. of fractured ribs (mean)	6.3	5.95
Presence of pulmonary contusion(number of patients)	90	103
Thoracic deformity(number of patients)	71	94
Mechanical Ventilation(mean number of days)	5.62	7.66
ICU stay (mean number of days)	8.19	10.14
Hospital stay(mean number of days)	16.09	19.47
Pneumonia (number of patients)	32	53
Mortality (number of patients)	3	7

The most common causes of trauma described in the studies were road accidents, followed by falls and assault. Rib fractures are a frequent pathology after a traumatic event.

Male patients seem to be commonly affected by thoracic trauma. The youngest patient involved in this study was 18 years old and the oldest 72.

Patients who suffered pulmonary contusions spent almost the same period in ICU and on mechanical ventilation whether they were operated or received medical treatment. Patients that received surgical treatment spent less days on the ICU ward, were weaned faster from mechanical ventilation and had a lower pneumonia rate than patients that received conservative treatment.

We also noted that after the intervention the patients left their bed earlier than the patients who did not suffer a surgical procedure - this helps with the restoration of the damaged lungs and avoids pulmonary complications.

DISCUSSION:

Surgical indication for rib fractures remains even today a controverted subject. It focuses on the full restoration of the integrity of the thoracic wall and aims to improve the physiological and social alterations that progress after rib fractures.

The vast majority of trauma surgeons have neither executed nor observed a surgical intervention for rib fracture are not familiar with surgical indications and available literature.

Rib fracture management includes appropriate ventilation, fluid therapy, pain management and management of the paradoxical movements of the thoracic wall. Internal stabilization achieved through mechanical ventilation has been proven lucrative in complicated cases [16].

Older methods of treating flail chest are represented by external traction and external stabilization. External traction is based on perpendicular traction of the fractured ribs to tie-rods. One of the primeval external stabilization methods implies strapping adhesive tape on to the chest wall or strapping and pressing sandbags on the thorax [17, 8].

Some surgeons (Hagen, Elkin) [26, 27] sutured the fractures either with metal wires or sutures, while others conceived different plates to stabilize the chest [29, 30]. Kirschner described introduction of metal pins in the central cavity of ribs. Labitzke [31], Judet [32] and Sanchez [38] described plates which are based on the principle of grasping the soft bone of the ribs with flat hooks instead of relying on screws. Strasbourg thoracic osteosynthesis system is a system based on the same fixation mechanism as the Judet plate and includes bars that can be connected to the plates to bridge or suspend thoracic wall segments [28]. Osteosynthesis with titanium components has replaced steel due to the low friction coefficient and the high corrosion-thermal-mechanical resistance, despite their low density. There are many types of plates and their application methods are assorted [13]. Absorbable plates agreeable for rib stabilization made from poly-L-lactide are conceived to dissolve within 18–24 months [35].

Vacuum Assisted Closure® is a new noninvasive method based on negative pressure in order to treat flail chest. Pieces of open-cell foam are applied externally and the entire damaged area is covered with a transparent adhesive membrane to a vacuum source. [20]

Using surgical stabilization of rib fractures is starting to increase, although criteria necessary for intervention is still debated. Less than 1% of patients with flail chest undergo surgery. Fracture stabilization of rib fractures provides many short term benefits (less time spent in the ICU, less time on mechanical ventilation, shorter period of hospitalization, less pulmonary complications and smaller mortality rates), but no studies highlight long term effect [42, 43, 44].

Should we stabilize one or both sides of a flail segment? Is fixation of every other broken rib as effective as stabilization of every fracture? Should we commonly omit certain ribs from the need to surgically mend?

The first two ribs do not play a great role in the respiratory function and are laborious to expose when a surgical stabilization method is performed. In a similar fashion, free floating ribs situated very low do not command reconstruction. Selective stabilization is more rapid, straightforward, cheaper, and sometimes less invasive. This is a chapter that has not been scientifically addressed and further study is adamant [37, 38, 39, 40].

Although enrolled patients in our pool analysis represented a relatively small sample size and the investigated parameters were not completely consistent in all 4 studies, we were able to find the following:

- male patients seem to be more prone to thoracic trauma and rib fractures rather than female patients,
- recovery rate and time depend most on the severity of the sustained lesions,
- patients that present a larger number of fractured ribs are more liable to receive surgical treatment than patients with less fractured ribs,
- when pulmonary contusions are associated to rib fractures the amount of time spent in ICU is almost the same whether patients received fixation surgery or medical treatment,
- Patients in the surgical groups seem to be weaned faster from mechanical ventilation, leave their bed earlier, present lower pneumonia and mortality rates and leave the hospital faster.

Three of the four studies involved in this analysis [48, 49, 50], suggest that surgical treatment of rib fractures brings substantial differences to a patient's evolution, while the other paper suggests the contrary. The pooled analysis advocates in favor of surgical management of rib fractures.

Available literature does not provide clinical randomized-controlled trials comparing which osteofixation method is better. Also, clinical trials that compare different surgical methods used to treat the same injury are deficient. Further research is required in this domain in order to properly establish a guideline regarding patient selection, stabilization method and outcome.

CONCLUSIONS.

There is a relatively small number of patients included in this study, the results still raise the question of whether surgical intervention or conservative treatment provides the best outcomes (both short and long-term) of patients.

Surgical management of fractured ribs may provide some critical care advantages in the critical care of severe multiple trauma patients, including using less medical resources and smaller risk of respiratory complications. Further well-designed studies with a sufficient sample size are required to confirm these results and to establish a possible advantage also in decreasing mortality.

Indications for operative management of fractured ribs are still shrouded in controversies, and challenges. Further research is required in this domain in order to properly establish a guideline regarding patient selection, stabilization method and outcome.

We consider that treating fractured ribs requires a team approach and that a favorable evolution of the patient requires attachment to the principles of orthopedic instrumentation, minimal tissue stripping, protecting the intercostal muscles, pleura and lung tissue, and adequate management of pain.

Conflict of Interest. Authors have no conflict of interest to disclose

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